Sept 19, 2012

___ Decision

___ Discussion

___ Information

SUBJECT: **Recommendations for Monitoring Potential Animal Impacts from Agricultural Lands**

ISSUE: **Agricultural production of animal products can have water quality impacts that are delivered via stormwater or direct deposit to streams. These include impairments in: sediment, pH, dissolved oxygen, nutrients, fecal coliform, and certain metals, impairing beneficial uses for salmon and other fish species, humans, and aquatic ecosystems as a whole.**

In terms of regulatory oversight, there are two basic categories of livestock farms: those that have specific requirements under either the state dairy nutrient management program, the Concentrated Animal Feeding Operations (CAFO) permit system, County Critical Areas Ordinances; and those that do not. Dairies and permitted facilities operate under a system that collects information about the potential impacts and addresses those impacts with Best Management Practices (BMPs). Follow-up monitoring includes implementation monitoring, soil tests, and occasional water quality investigations. While all dairies are covered by the state dairy program, there are currently a small number of CAFOs that are covered by the permit. Most animal husbandry operations are not part of either system, resulting in a lack of information about where and how much total potential impact exists within a watershed or sub-watershed.

Also, once potential impacts are identified, areas need to be prioritized and a successful process needs to be applied to address the problems. Lastly, follow-up monitoring is needed to assure that water quality has improved to the level expected.

The recommendations described below provide a framework to: 1) identify and prioritize potential problem areas, 2) conduct an adequate process that can successfully address the issues, 3) use source identification monitoring to define specific problem farms, 4) address the problems with BMPs, and 5) conduct follow-up monitoring at a sub-watershed scale to confirm that the BMPs are implemented and have adequately addressed the problem. Lastly, we recommend that source identification for livestock impacts incorporate the suggested parameters in the attached source ID guidance paper.

BACKGROUND:
Which types of monitoring and assessment information are needed and why?

The Agriculture Stormwater Sub-Group reviewed existing information regarding agriculturally-produced animal products in Puget Sound. They found that not only is monitoring lacking for many types of animal husbandry, but there is no process or strategy in place to address problems for farms that are not under a permit system. Also for all animal facilities, follow-up water quality monitoring at a broader scale is uncommon and needed to ensure that enough actions have been done to achieve standards where it counts: in the stream or ecosystem.

The current situation is that dairy farms and permitted CAFOs have oversight from the Departments of Agriculture and Ecology. The current level of monitoring for these activities are: 1) best management practices (BMPs) are monitored for implementation (were they installed and are they in use); 2) soil tests for nitrogen and phosphorus when manure and fertilizer is applied on cropland; 3) discharges are investigated; and 4) existing ambient water quality monitoring can be examined to assess water quality impacts. However, water quality measurements may have little correlation to stormwater events. The conclusion is that while there is existing monitoring of the practices on dairies and the few permitted operations, it should be expanded to all dairies and CAFOs. Also, larger scale (watershed or sub-watershed) water quality monitoring is generally lacking, especially when related to stormwater.

All other animal-related farms are not under an oversight system and no monitoring or record-keeping is required. This includes heifers, feedlots, non-beef, and small/hobby farms. For these types of farms, the current situation is: 1) inventories of animals have been done in some districts, but not across the Puget Sound region; 2) Some of these inventories included prioritization of farms based upon a potential to pollute; 3) up until now, little guidance has existed on how to conduct adequate source identification monitoring to define problems and problem areas and how to use this information where it exists to improve water quality.

The desired situation for all types of animal-related farms is described in the recommendations below. It includes collecting needed information on non-permitted farms, applying a strategy that is believed to be successful in addressing agriculture-related livestock problems, and guidance regarding what and how to monitor.

Who was involved in the Subgroup, and how were decisions made?
Members of the Agriculture Subgroup are: Heather Kibbey (City of Everett), Mike Shelby (Western Washington Agriculture), Jay Gordon (Washington Dairy Federation), Karma Anderson and Dino Marshalonis (EPA), Bob Cusimano and Ron Cummings (ECY), Monte Marti and Bill Bowe (Snohomish Conservation District), Karen Bishop (Whidbey Island Conservation District), Sherre Copeland and Clare Flanagan (NRCS), Nora Mena (Washington Dept. of Agriculture), Rick Haley and Michael See (Skagit County), Joe Holtrop and Meghan Adamire (Clallam Conservation District), Carolyn Kelly (Skagit Conservation District), John Bolender (Mason Conservation District), Rosie Taylor (Jefferson Conservation District), George Boggs (Whatcom Conservation District), Heather Trim (People for Puget Sound), Richard Doenges (Thurston County), Adam Lorio (Samish Indian Nation, and Carol Smith (Washington Conservation Commission). These individuals had the opportunity to review and comment on all products, but do not necessarily endorse all the recommendations.

Products included meeting summaries from four meetings: March, May, July, and August 2012. The recommendations were developed primarily in the March and May meetings. They were reviewed and finalized for submission to the Puget Sound Stormwater Workgroup during the August 9 meeting. In attendance at that meeting were: Heather Kibbey (City of Everett), Monte Marti (Snohomish Conservation District), Rick Haley (Skagit County), Karen Bishop (Whidbey Island Conservation District), Bob Cusimano (ECY), Karma Anderson (EPA), Meghan Adamire (Clallam Conservation District), Mike Shelby (Western Washington Agriculture), and Carol Smith (WA Conservation Commission). A mix of participants was present at the March, May, and July meetings when this product was under development.

Decisions were reached by consensus.

Where are we in the SWG approval process, and when are decisions needed?
Recommendations will be presented at the September 19th meeting with decision at the October meeting.

How and when are recommendations envisioned to be implemented?
The agriculture stormwater subgroup will develop an implementation and funding plan in a future set of meetings. We want to develop this plan after we have a full set of agriculture recommendations to facilitate prioritization. Also, we only want to develop this plan for approved recommendations.

What are the funding implications?
See above answer.

ALTERNATIVES CONSIDERED:

Additional possible alternatives:

1) No recommendations. No change or improvement. Lack of coordination across areas.
2) Require all operations to have permits or meet some established minimum criteria. Not likely acceptable options politically. Lack of capacity.

RECOMMENDATIONS AND REASONING:

Identify problem areas to a sub-watershed level to prioritize areas for detailed monitoring and implementation. Significant data gaps exist, especially regarding the extent of potential problem areas associated with small (unpermitted) livestock farms. Key questions needing data are, to what extent do farm animals contribute to pollutant problems in Puget Sound during stormwater events and in which sub-watersheds should we focus resources initially? Our first recommendation is to better identify those areas that are lacking information about livestock numbers and their potential impacts. The second recommendation is to use that information along with water quality data to prioritize those sub-watersheds with high potential impacts for initial action.

Recommendation 1. Fill data gaps for non-dairy, non-permitted operations in animal numbers, types, location, proximity to water bodies, BMPs in use, BMPs needed. This information is not easily documented. To facilitate this action, we have a few examples of forms and prioritization methods that can be used by others (Appendix 1), although most importantly, the survey should include the above-listed data fields. Surveys have been completed in Whatcom, Samish, Clallam, Stillaguamish, Snohomish, and King County watersheds.

Recommendation 2. Use this farm information along with other triggers to assess whether the potential impact is high enough to warrant additional monitoring. Other triggers include the presence of a TMDL for agricultural parameters in an area with significant agriculture; documentation of downstream problems potentially relating to agriculture such as shellfish bed closures, and water quality results (i.e., status and trends monitoring) that indicate problems. Note: one member does not agree with this recommendation. Wants stronger language such that all animal owners manage animal husbandry to the appropriate level.

Conduct an adequate process to successfully address the problems. Once a high priority problem area has been identified, apply the following strategy to better define the problem and then address the problem using source ID monitoring. These recommendations will address the following questions:

- What are the relative roles and value of community involvement, voluntary compliance, and enforcement in solving farm animal pollution?
- How do we effectively monitor and then reduce and prevent the impact of farm animal waste?
- Are current monitoring efforts sufficient for permitted or dairy facilities? For unpermitted facilities?

Recommendation 3. For high priority areas, further define the problems, while obtaining community support:

a. Conduct community outreach to elevate the issue and obtain support. Define the community to be small enough to be effective. If community support is not present, the remaining actions won't be very successful.

b. Collect detailed survey information for all potential sources of impact in that area. This includes non-ag, small farms, permitted and dairy facilities, and other commercial operations.

Recommendation 4.

c. Conduct source identification monitoring or bracket water quality monitoring around storm events to better characterize the sources of pollutants in these high priority areas. Can use the suggested parameters developed in this process (Appendix 2).

Recommendation 5.

d. Implement best management practices (BMPs) to address the identified sources of problems. Monitor the implementation and maintenance of BMPs.

e. Develop a regulatory backstop and apply if needed. Examine the existing enforcement process in an area. Is it well-defined, well-communicated, and sufficient? Some areas do not have regulation occurring and may need additional enforcement staff and funding. In the meantime, work harder on community support, especially with current lack of funding.

Recommendation 6.

f. Conduct follow up monitoring and adaptive management to mark progress and implement additional practices.

g. Find the necessary technical and financial support that are needed throughout the process.

Provide guidance for choosing source identification parameters for livestock farms.

Recommendation 7. Provide and encourage source identification monitoring for livestock impacts to use the guidance in Appendix 2. This is a suggested list of parameters needed for initial source identification monitoring for livestock impacts.

These data are important to help answer the question:

- How can bracket monitoring better identify problem areas and subsequent changes/improvements after BMP implementation?

Appendix 1. Examples of Forms or Processes Used for Successful Livestock Surveys and Prioritization of Potential Impacts.

Example 1. Clallam Conservation District.

AGRICULTURAL WATER QUALITY REMEDIATION STRATEGY

STEP 1 – INVENTORY OF FARMS COUNTYWIDE - 1,252 Farms Inventoried in 2006

Performed a windshield survey of the entire county driving down all roads. Using hardcopy maps farm parcels were outlined based on field observations and assigned a farm number. The farm number and following information were entered into an access database on a laptop brought into the field:

- Parcel site address which was linked to a spatial database for mapping and data analysis
- Number and type of livestock
- Types of crops and acreage estimates
- Notation of parcels with general agricultural activities such as poultry, apiaries, farm stands, flowers, hay, nurseries, etc.
- Farms "ranking" based on their potential to impact water quality (high, medium, low). Took into account horse/livestock access to waterways, waterways with outlets, proximity of manure piles and wintertime confinement areas to surface water, etc.

STEP 2 – PRIORITIZE FARMS according to potential impacts to surface water quality

MEDIUM and HIGH POTENTIAL IMPACT = HIGH PRIORITY

125 High Priority Farms Countywide

STEP 3 – PRIORITIZE FARMS by WRIA, WATERSHED and SUBWATERSHED

STEP 4 – DESCRIBE HIGH PRIORITY FARMS according to status with District

COOPERATORS – describe status (why are they still High Priority?)

NO RECENT or PREVIOUS CONTACT

UNCOOPERATIVE

STEP 5 – CONDUCT REGIONAL WORKSHOPS targeting HIGH PRIORITY FARMS

STEP 6 – INITIATE OUTREACH EFFORTS to HIGH PRIORITY FARMS

1. THREE CRABS AREA
2. Remainder of DUNGENESS BAY WATERSHED
3. Remainder of CLEAN WATER DISTRICT

Multiple contacts/visits over several months may be necessary before achieving cooperation.

STEP 7 – PROVIDE TECHNICAL and/or FINANCIAL ASSISTANCE to HIGH PRIORITY FARMS

If necessary to mitigate water quality impacts

STEP 8 – IF COOPERATION IS UNACHIEVABLE

Next steps will be evaluated on a case-by-case basis.

STEP 9 – ADD FARMS TO THE HIGH PRIORITY LIST AS NEEDED

Any HIGH PRIORITY FARM requesting assistance is a top priority, regardless of geographic location. If resources are insufficient to meet demand, high priority farms will be prioritized according to geographic location. Geographic priorities are listed under STEP 6. A LOW PRIORITY FARM may be considered a high priority to assist if other factors, including status in the community help achieve outreach goals in region.

Example 2. Snohomish Conservation District.

- What data has been collected and how collected?
    - Snohomish CD has collected a lot of "visual" livestock inventory data over the years. The latest were two priority watersheds within the Stillaguamish Clean Water District. Data collected was done via windshield surveys, on county roads. The staff did not go down private drives or roads.
    - SCD also did follow-up on completed farm plans over a period of 10 years to determine the efficacy of implementation. This was done via phone calls and surveys as a way to reconnect with landowners. We found this a very useful tool to identify BMPs that had been developed after a grant or contract ended, and determine why they moved forward with implementation and were they maintaining the BMP. It also provided a way to assess why people weren't implementing BMPs.
    - SCD has also collected some livestock survey data via GPS technology.
    - Other data collected was manually written down on each site according to numbers/type of livestock, BMPs implemented, BMPs lacking, type of wetland/waterway or critical area, access by livestock to water, notes for discussion to help prioritize site based on water quality.
- How is the data analyzed or summarized (if it was?)
    - Data was manually put into an Access database, and any GPS coordinates were loaded. It was then downloaded to a spreadsheet where we used pivot tables to analyze the data. This allowed us to figure out percentages, and help prioritize "hot spots." It also allowed us to determine the amount of BMPs that were on the ground as well as how much was lacking.
- How was it used to prioritize workload or assist in decision making?
    - This data allowed us to determine and sort the "high risk" properties to use as a priority for funding as well as a priority for follow-up and continued effort within these watersheds. The watersheds were prioritized for survey work by the Stillaguamish Clean Water District and their proximity and/or impacts to shellfish beds and water quality based on TMDLs, local knowledge, and existing water quality data.

Example 3. Department of Ecology.

Livestock and Water Quality Site Visit

Site Visit Information ☐ First Visit ☐ Follow-up Visit

Prepared by: _____ Arrival Time:_____ Depart: _____

Date:_____ Current Weather Conditions_____

Owner/Operator

Name: _____ Street:_____

Phone: _____ City: _____

E-mail:_____ Zip:_____

Site Details

County: _____ Watershed:_____

General Site description (include information on nearby water bodies and description of farm conditions):_____

_____

_____

_____

_____

_____

_____

_____

Site Evaluation

1) Stream Corridor and Other Areas Near Surface Water: ☐ Evaluated ☐ Not Evaluated

- ☐ Bare, exposed, eroding soils
- ☐ Contaminated run-off (active or potential)
- ☐ Slumping stream banks and erosion
- ☐ Overgrazing of grasses
- ☐ Absence of woody vegetation
- ☐ Manure accumulations
- ☐ Animal access to surface water
- ☐ Livestock paths and trails along riparian areas

Comments:_____

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2) Confinement Areas: ☐ Evaluated ☐ Not Evaluated

- ☐ Distance to surface water (_____ft)
- ☐ Presence of mud and manure
- ☐ Polluted runoff leaving the area
- ☐ Signs of polluted run-off leaving the area
- ☐ Signs of previous runoff into surface water
- ☐ Polluted run-off reaching surface water
- ☐ Roof runoff water flows to confinement areas
- ☐ Adjacent land slopes toward surface water

Comments:_____

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3) Stock water: ☐ Evaluated ☐ Not Evaluated

- ☐ Distance to surface water (_____ft)
- ☐ Overflow from tanks on to the ground
- ☐ Mud and standing water at tanks
- ☐ Animals accesses stream for stock water

Comments:_____

_____

_____

_____

4) Upland Pasture Areas: ☐ Evaluated ☐ Not Evaluated

- ☐ Animal access to stream corridors
- ☐ Distance to surface water (_____ft)
- ☐ Signs of overgrazing and erosion
- ☐ Manure accumulations and bare ground

Comments:_____

_____

_____

_____

_____

***5) Manure Management*:** ☐ Evaluated ☐ Not Evaluated

Current manure management plan?_____

Manure collected and stored?_____

Manure storage properly sized?_____

Manure storage covered?_____

Manure being collected often?_____

Manure stored on an impervious surface?_____

Applied during growing season?_____

Manure applied during non-growing season?_____

Vegetated buffer when manure is applied?_____

Manure disposed off site?_____

Comments:_____

_____

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Other Areas of Concern/General Comments

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☐

Corrective Actions Required

☐ Install livestock exclusion fencing to keep animals at least _____ft from surface waters (35ft minimum) The exclusion area should be comprised of native shrubs and trees suited to the soils and hydrology of the site.

☐ Install off-stream stock water watering facilities and locate them at least _____ ft from surface to prevent risk of water quality impacts (minimum of 75ft)

☐ Collect manure frequently and store it in a dry, covered area with an impervious floor or deck

☐ Apply manure during the growing season at proper rates and times (minimum of 100ft setback from surface water, or the use of a 35ft vegetative buffer)

☐ Site and design confinement and manure storage areas to prevent pollution of surface and ground water

☐ Provide heavy use protection in confinement areas and at stock tanks to prevent run-off

☐ Construct stream-crossings and emergency water locations in ways that protect the stream

☐ Other Actions _____

Photos Taken: ☐ Yes ☐ No Samples Taken: ☐ Yes ☐ No Conservation District Referral: ☐Yes ☐No

General Comments:_____

_____

_____

Appendix 2. What parameters should be monitored to support Source ID?

Microbiological Examination Measurements

Fecal coliform
E. coli
% KES
Enterococcus
Chloride and Specific Conductance

Fecal wastes carry bacteria that can cause diseases in humans and animals directly by drinking (gastrointestinal illness) or swimming (ear, nose, throat, and skin infections). Indirect contact by eating contaminated food (shellfish) and getting contaminated water on your hands can also cause illness. Since there are so many possible disease organisms, researchers have tried to find bacteria organisms that are easily tested and commonly found in fecal wastes. There are several bacteria indicators. Each has its own history, strength and weakness.

Fecal coliform (FC) using both the membrane filter (MF) and most probable number (MPN) methods. FC is a family of indicator bacteria for manure and fecal wastes sources, but also decaying vegetation. FC is the indicator used in Washington State Water Quality Standards to determine the primary and secondary water contact recreation use of freshwater and primary contact recreation in marine waters. The MF method is quicker and provides better precision. The MPN method is more conservative and is compatible with FDA and Washington Department of Health Shellfish Protection Program regulations for shellfish harvest areas.

E. coli is a more specific test for fecal sources from warm-blooded animals, and is recommended by EPA as a superior indicator organism in freshwater.

% KES (Klebsiella, Enterobacter, and Serratia) confirms what portion of the FC count is from vegetative sources.

Enterococcus is another group of fecal bacteria within the fecal streptococcus group. EPA now recommends Entercoccus for measuring marine water sanitation for secondary contact recreation. The FC/fecal streptococcus ratio was popular at one time to try and differentiate between human and animal wastes. Researchers generally found the ratio works only if samples are collected close to a fresh source of fecal material.

Chloride and Specific Conductance measurements are used to track potential sources of wastes. The background levels in rivers and streams in western Washington are fairly low until

estuarine environments are encountered. The measurements will not change unless sources with higher or lower levels are added to the waterway. Liquid wastes like sewage and manure have high concentrations of chloride and high specific conductance readings. When a significant source of wastes is discharged into the waterway, the increase in the chloride and specific conductance is observable downstream and becomes stronger closer to the source.

Solids Measurements

Total suspended solids
Total non-volatile suspended solids
Total volatile suspended solids
Turbidity

Erosion of sediment into waterways is a natural process, but too much sediment in waterways can be the result of poor land management practices. Suspended solids and sediment can directly harm aquatic organisms by damaging gills of swimming organisms and suffocating organisms living on the bed of the stream, lake or estuary. Suspended solids can also interfere with feeding, behavior, and movement of aquatic organisms, and block light penetration into the water. Also, sediments and other solids transport other pollutants like bacteria, '\]
[[oils, pesticides, and phosphorus that bind to solids particles. Other solids in the water column besides sediment are organic materials from plants, algae, or other tissues growing in the water or mechanically broken-down by biological, chemical and physical processes in the water. An excessive amount of algae or sediment in the water column can be a problem for heat retention, light penetration, visibility for swimming and boating safety, and aesthetic enjoyment. The problem of suspended sediment and solids in the water column is one of both intensity of the concentration and the duration that intensity is maintained.

Total suspended solids is a measurement of the amount of material in the water column that is retained when the sample is filtered. The measurement can then be used to estimate the pounds or tons of material being transported. Depending upon the species and life-stage of the fish, concentrations as low as 10 mg/L – 20 mg/L over months of time can result in sub-lethal effects like interference with feeding behavior, hatching rates, growth rates and disease resistance. Months at 100 mg/L, and weeks or a few days of concentrations above 1000 mg/l could be lethal to a majority of a local aquatic community.

Total non-volatile suspended solids measures the portion of the suspended material that is not organic (by burning the sample in an oven) – mainly sediment materials. By subtracting the non-volatile portion from the total suspended portion, the organic or total volatile suspended solids fraction is found.

Turbidity is a measure of transparency of the water in nephelometic turbidity units (NTUs). It is regulated in the Washington State Water Quality Standards by reference to a control sample upstream of a source (not more than 5 or 10 NTUs over background). Particles that float or sink easily are not adequately measured by turbidity procedures. If the particles are suspended uniformly and suspended solid particles are not too heavy or light, turbidity can be highly correlated with total suspended solids.

Dissolved Oxygen, pH, Nitrogen, and Phosphorus Measurements

Dissolved Oxygen (DO)
pH
Nitrogen (ammonia, nitrate-nitrite, total N)
Phosphorus (total P and soluble reactive P)

Dissolved oxygen (DO) is regulated primarily to ensure fish survival. Washington State Water Quality Standards are very salmon oriented. Since salmon spawn in gravels, the DO concentrations required in the water column are high to keep salmon eggs and embryos in the gravels aerated. Since DO levels in a healthy water body naturally swings to a maximum concentration during the day and a minimum at night, the one-day minimum concentration is regulated but the range between the maximum and minimum is also of interest. The one-day minimum concentration allowed is 8 mg/L for salmon migration, rearing and spawning. However, DO in some salmon areas cannot go below 9.5 mg/L. Warm water fisheries without salmon only require 6.5 mg/L DO (none of these have been designated yet). Maximum and minimum DO concentrations are affected by reaeration, temperature, biological activity, and chemical reactions. Turbulent, shallow water will increase mixing with the atmosphere and raise DO concentrations; slow and deep water will not mix as well and can have lower DO. Higher temperatures will increase oxygen movement from the water to the atmosphere and decrease DO in the water.

Algal growth, stimulated by nutrients, will increase DO concentrations in the daylight as algae produce oxygen, and decrease DO concentrations at night as algae respire. As bacteria breakdown organic materials, they use oxygen.

pH is a measure of the hydrogen ion activity in the water. Water bodies usually have a neutral pH near 7 units. Under acidic conditions, pH moves down the scale to 6.5 units or less. Basic conditions cause the pH to rise to 8 or 9 units. Surface waters in Washington generally fall within the 6.5 – 8.5 unit Water Quality Standards. This range is considered healthy for aquatic organisms and prevents some metals from disassociating and becoming toxic to aquatic organisms. Higher pH values also increase the unionization of ammonia – increasing its toxicity. The pH is moderated in freshwater by carbonate reactions. If CO2 is produced by bacterial decomposition of organic material, algal respiration, or interchange with the atmosphere, then pH will drop. As carbonates are formed from geochemical sources or algal productivity, then the pH will rise.

Nitrogen and its compounds are present in most plant and animal materials and consequently are present in decaying matter. Waters draining agricultural areas may contain high levels of the different forms of nitrogen. Ammonia in large quantities is toxic to aquatic life and levels should generally be <0.02 mg/L in non polluted freshwater. [*Note*: If stormwater discharges directly or indirectly to nutrient-impaired marine water, then nitrogen measurements will be important.]

Phosphorus is an essential plant nutrient and may be limiting factor for plant growth in freshwater. In comparison to other major nutritional and structural components in biota,

phosphorus is rarely found in significant concentrations in surface waters for two reasons: there is only a relatively small amount available in the hydrosphere, and what is available is actively taken up by plants. As with nitrogen, waters draining agricultural areas may contain high levels of the different forms of phosphorus and can be a major pollutant that leads to eutrophication processes. [*Note:* Phosphorus is closely associated with sediments. It can absorb to sediments in overland flow processes and especially in erosional processes.]

Copper, Zinc, and Hardness Measurements

Copper and zinc are common heavy metal constituents of water and are essential for all plant and animal life. However, research has well established that higher levels of dissolved copper and zinc can be toxic to aquatic organisms including salmon. Copper sulfate is used in a wide range of application products in agriculture such as fungicides, pesticides, and herbicides. Zinc is present in fertilizers and animal feeds and mineral premixes. Copper and zinc are normally measured as both the total and dissolved fraction.

Hardness is a measure of dissolved minerals in water such as aluminum, calcium, iron, and magnesium, although it is mostly determined by the sum of calcium and magnesium. The toxicity of most heavy metals including copper and zinc in freshwater is a function of hardness.